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SOLAR OBSERVATIONS

DIFFERENCES BETWEEN AMERICAN AND EUROPEAN RESULTS FOR β AND w

By Herbert H. Kimball, Research Assistant, Harvard University

In the Monthly Weather Review for November 1936, page 377, I published a brief reference to differences that appear in the values of β, the atmospheric turbidity factor, as obtained at European and at American meteorological observatories, which seemed to be due largely to methods of computation or else to differences in the fundamental data on which the computations are based.

In this note I also called attention to an alleged error in the method that had been followed at the United States Weather Bureau, and later at the Blue Hill Meteorological Observatory, in computing β. Later, it was pointed out (Monthly Weather Review, December 1936, p. 430) that in reality no error had been made. This confusion of thought on my part was due to the strain of overwork in keeping Blue Hill observations reduced and published on time, in addition to revising methods of reduction.

In the meantime a letter was received from Dr. Feussner, Director of the Potsdam Magnetic and Meteorological Observatory, who had been very helpful in procuring and standardizing the color screens that are used in obtaining measurements of the intensity of solar radiation in certain designated sections of the spectrum. He suggested that in the United States we adopt the system of curves which are used at European observatories and which have been sanctioned by such eminent European scientists as Ångström, Hoelper, and Süring. I readily agreed to this proposal, since a casual examination showed close agreement between these curves and those that had been computed by me, and especially since my curves were made at my home, immediately following my retirement from the Government service, where conveniences for accurate work were meagre.

The use of the European curves was to have begun with the data for January 1937; these data reached me from Blue Hill on February 3. The morning of January 1 at Blue Hill had been unusually clear; the unscreened solar radiation, expressed in units on the Smithsonian Pyrheliometric scale, at solar altitude 22°22' (air mass, 2.61) was 1.356. Reducing this air mass by 0.2 percent on account of the reduced air pressure at the summit of Blue Hill, I found that the measured intensity falls above the curve for $\beta=0$ on the European diagram. At solar altitude 23°28', shortly before noon on this same day, air mass 2.50, the measured intensity was 1.384. Reducing the air mass for air pressure at the summit of Blue Hill to 2.45,

I found this value also falls above the curve for $\beta=0$. The corresponding values of β and w, computed from the curves published by me in the Monthly Weather Review, March 1933, page 82, are as shown in table 3.

A hasty examination indicates to me that while for $m=1.0$, and $\beta=0$, the American curves for I_m give an intensity of 91.2 percent of the solar constant, the European curves give only 89.8, or a difference of 1.4 percent. The difference increases, of course, with wave length. Measurements at Blue Hill during January are most frequently made with air masses of about 2.5 to 4.0.

It seems necessary, therefore, to continue to use the American curves until an error is shown in them that will explain the above discrepancies.

SOLAR RADIATION OBSERVATIONS DURING JANUARY 1937

By Irving F. Hand, Assistant in Solar Radiation Investigations

For a description of instruments employed and their exposures, the reader is referred to the January 1935 Review, page 24.

During January 1937 at Washington there were fewer days on which normal-incidence observations were obtained than in any other month during which this type of measurements has been made, that is, since October 1914. As but one observation was made at each air mass, little may be said about the departures from normal at Washington. The observations at Madison and Lincoln were close to normal for the month, as also were those at Blue Hill, for which departures from normal are computed for the first time since the beginning of solar observations there nearly four years ago.

Table 2 shows a deficiency in the total solar and sky radiation at all stations except those on the west coast: Fresno, La Jolla, and Friday Harbor; and also the mid-Plains city of Lincoln.

Neither polarization nor turbidity determinations were made at Washington during January because of the large percentage of cloudiness.

LATE DATA

The values of the total solar and sky radiation expressed in gram calories per square centimeter for the weeks beginning December 3, 10, 17, and 24, 1936, for Fairbanks, Alaska, are 11, 5, 8, and 3 with departures of +4, 0, +2, and −2, respectively. For the year Fairbanks had a minus departure of 2,576 gram calories, or a percentage departure of 5.6.

TABLE 1.—*Solar radiation intensities during January 1937*

[Gram-calories per minute per square centimeter of normal surface]

WASHINGTON, D. C.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	\multicolumn{9}{c}{Air mass}	Local mean solar time
		\multicolumn{4}{c}{A. M.}	¹ 1.0	\multicolumn{4}{c}{P. M.}	
	θ	5.0	4.0	3.0	2.0		2.0	3.0	4.0	5.0	θ
	mm	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm*
Jan. 14	8.48										10.59
Jan. 16	10.97	0.59	0.76	1.06							2.87
Jan. 27	2.26				1.22			1.23	1.14	1.00	1.96
Means		(.59)	(.76)	(1.06)	(1.22)			(1.23)	(1.14)	(1.00)	
Departures		−.16	−.10	+.03	−.22			+.18	+.24	+.18	

LINCOLN, NEBR.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
Jan. 5	1.12							1.16	0.97	0.85	3.15
Jan. 11	.71							1.24	1.00	.89	1.96
Jan. 12	1.07		1.03	1.20							1.68
Jan. 13	3.45							1.12	.98	.84	4.37
Jan. 14	.91	0.86		1.08							.91
Jan. 15	.71	.86	1.09	1.32				1.26	1.12	1.00	.81
Jan. 16	1.45	.89	.96								2.74
Jan. 22	.66					1.44	1.42	1.26	1.10		1.12
Jan. 23	.64		1.14	1.32	1.47						1.68
Jan. 25	.79	1.04	1.11	1.27	1.40		1.24	.97	.91	.82	1.02
Jan. 26	1.32						1.30	1.07	.84	.70	2.26
Jan. 27	2.36	.91	1.04	1.15	1.30						3.99
Means		.91	1.06	1.22	1.39		1.33	1.18	1.01	.89	
Departures		−.01	+.01	+.03	+.01		−.03	.00	−.04	−.04	

TABLE 1.—*Solar radiation intensities during January 1937*—Contd.

MADISON, WIS.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	\multicolumn{9}{c}{Air mass}	Local mean solar time
		\multicolumn{4}{c}{A. M.}	¹ 1.0	\multicolumn{4}{c}{P. M.}	
	θ	5.0	4.0	3.0	2.0		2.0	3.0	4.0	5.0	θ
	mm	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm*
Jan. 11	1.60	0.76	0.92	1.12	1.36						1.96
Jan. 12	1.78	.92	1.01	1.11	1.34			1.02			2.06
Jan. 18	1.24	.73	1.06	1.19	1.44			1.38			1.07
Jan. 23	.46			1.09	1.46						.79
Jan. 25	1.32	.64	.77	1.01	1.22						1.19
Jan. 27	1.60				1.24			.95			2.06
Means		.76	.94	1.10	1.34			1.12			
Departures		−.19	−.11	−.11	−.01			−.03			

BLUE HILL, MASS.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
Jan. 1	2.3	1.22	1.28	1.35	1.46						2.5
Jan. 4	2.1		.97	1.10			1.28	1.05	0.88	0.76	2.0
Jan. 5	3.2	.91	1.07	1.22	1.35					.84	2.6
Jan. 6	1.3	1.04	1.16	1.30	1.45		1.45	1.20			1.3
Jan. 11	2.3			1.12	1.32		1.35	1.16			2.2
Jan. 13	3.8	1.04	1.13	1.21	1.31		1.38	1.21	1.00		2.8
Jan. 16	2.5							.96	.88		2.4
Jan. 27	1.0			1.24	1.35				.94		1.0
Jan. 28	1.2			.96	1.15						2.1
Jan. 30	3.1				1.36		1.36	1.28	1.13		2.3
Jan. 31	3.6			1.28	1.36						3.5
Means		1.05	1.12	1.20	1.35		1.36	1.14	.97	(.80)	
Departures		+.12	+.08	+.05	+.03		+.02	−.04	−.10	−.15	

¹ Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

Week beginning—	Gram-calories per square centimeter
	Washington	Madison	Lincoln	Chicago	New York	Fresno	Fairbanks	Twin Falls	La Jolla	Miami	New Orleans	Riverside	Blue Hill	San Juan	Friday Harbor	Ithaca
1937	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Jan. 1	128	98	118	74	112	195	4	131	219	290	177	220	142	247	102	101
Jan. 8	102	121	217	81	110	214	3	152	234	274	202	211	137	357	76	78
Jan. 15	61	134	232	92	65	284	9	177	285	286	168	269	69	411	107	36
Jan. 22	102	185	277	106	120	228	24	181	297	328	152	194	143	403	81	110
	Departures from weekly normals
Jan. 1	−46	−30	−54	−6	+8	+43	−3	−31	−12	−4	+11	−8	−3		+31	+4
Jan. 8	−70	−14	+31	−1	+2	+48	−5	−15	−26	−23	+10	−30	−10		−3	−10
Jan. 15	−121	−21	+34	−6	−44	+90	−4	−6	+7	+10	−30	+5	−96		+16	−66
Jan. 22	−101	0	+49	−13	−31	+3	−2	−6	+34	−4	−51	−73	−52		−16	−40
	Accumulated departures on Jan. 28
	−2,366	−455	+420	−182	−455	+1,288	+98	−406	+21	−147	−420	−742	−1,127		+196	−784

ON THE METHOD EMPLOYED FOR COMPUTING β AND W, SEE P. 18 OF THIS REVIEW.—ED.

TABLE 3.—*Total, I_m, and screened, I_v, I_r, solar radiation intensity measurements, obtained during January 1937 and determinations of the atmospheric turbidity factor, β, and water-vapor content, $w=$depth in millimeters, if precipitated*

BLUE HILL METEOROLOGICAL OBSERVATORY OF HARVARD UNIVERSITY

Date and hour angle	Solar altitude	Air mass	I_m	I_v	I_r	β_{mean}	$\dfrac{I_{w-o}}{1.94}$ Percentage of solar constant	$\dfrac{I_{w-o}-I_m}{1.94}$	w	Air-mass type
1937	° ′	m	gr cal.	gr cal.	gr cal.				mm	
Jan. 1										
1:17 a. m.	22 22	2.61	1.356	0.912	0.740	0.022	76.0	9.0	5.5	Pc
0:57 a. m.	23 28	2.50	1.384	.912	.748	.027	75.4	6.4	4.3	
Jan. 4										
2:04 a. m.	19 06	3.03	1.102	.602	.592	.023	73.2	18.6	10.8	Npc
Jan. 5										
2:42 a. m.	14 29	3.94	1.108	.764	.664	.058	66.7	11.5	6.6	Np
Jan. 6										
3:33 a. m.	8 35	8.88	.972	.692	.608					Pc
1:17 a. m.	22 53	2.56	1.316	.876	.724	.047	68.2	2.6	.6	
1:28 p. m.	22 10	2.63	1.204	.848	.696	.050	67.6	5.6	3.5	
Jan. 11										
1:56 a. m.	20 40	2.81	1.216	.792	.668	.050	66.0	15.1	9.1	Npc
Jan. 13										
2:14 a. m.	19 10	3.02	1.184	.784	.660	.056	64.0	.8	.5	Np
2:03 a. m.	20 14	2.88	1.208	.792	.664	.052	66.0	10.0	5.9	
3:37 a. m.	9 00	6.18	.980	.660	.560	.048	60.0	11.0	4.5	
Jan. 16										
3:01 p. m.	14 11	4.02	.879	.632						Pc
Jan. 27										
2:23 a. m.	21 46	2.68	1.256	.824	.685	.040	69.8	7.1	4.1	Pc
0:40 a. m.	28 38	2.08	1.268	.800	.664	.088	66.4	1.6	1.1	
3:12 p. m.	14 54	3.84	.968	.652	.576	.100	56.0	7.2	3.7	
Jan. 28										
3:32 a. m.	12 20	4.61	1.000	.680	.584	.090	65.0	12.3	5.8	Pc
Jan. 30										
1:38 a. m.	25 39	2.32	1.172	.752	.630	.105	60.8	2.2	1.5	Pc
0:35 p. m.	29 35	2.02	1.334	.848	.700	.055	71.5	4.8	3.4	

Atmospheric conditions during Smithsonian readings, Blue Hill Observatory, January 1937

Date	Time from local noon	° C.	Wind, Beaufort	Visibility	Sky blueness	Cloudiness and remarks
Jan. 1	1:32 a. m.	+4.9	WNW 3.	8	10	1 Ci., Light to Moderate haze.
4	2:16 a. m.	−1.9	W 3.	8	8	Few Acu., Light haze.
5	2:45 a. m.	0.0	SSW 5.	7	8	Few Ci., Moderate haze.
6	3:36 a. m.	−7.7	NW 5.	9	8	2 Ci., Light haze.
6	1:20 a. m.	−6.6	NW 3.	9	8	1 Ci., Light haze.
6	1:35 p. m.	−3.9	NNW 1.	9	7	3 Ci., Light haze.
11	1:59 a. m.	−3.9	NNE 1.	6	8	1 Acu., Dense haze.
13	2:18 a. m.	+0.1	W 1.	7	8	Few Ci., Moderate haze.
13	2:06 a. m.	+0.3	NW 1.	7	8	Few Ci., Moderate haze.
16	2:28 p. m.	−0.8	NW 4.	8	7	6 Cu., Light haze, Cu in front of sun.
16	2:59 p. m.	−0.6	NW 4.	8	7	6 Cu., Light haze, Cu in front of sun.
27	2:26 a. m.	−9.1	NW 4.	8	8	2 Cu., Light haze.
27	0:43 a. m.	−7.8	NW 4.	8	8	Few Cu., Light haze.
28	3:34 a. m.	−9.1	NNE 3.	5	8	1 Ci., Dense haze at low angle.
30	1:41 a. m.	−1.0	N 3.	6	8	Few Cu., Dense haze.
30	0:31 p. m.	0.0	NE 3.	8	8	Few Ci., Moderate haze.

POSITIONS AND AREAS OF SUN SPOTS

Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.), Superintendent U. S. Naval Observatory. Data furnished by the U. S. Naval Observatory in cooperation with Harvard and Mount Wilson Observatories. The difference in longitude is measured from the central meridian, positive west. The north latitude is positive. Areas are corrected for foreshortening and are expressed in millionths of the sun's visible hemisphere. The total area for each day includes spots and groups]

Date	Eastern standard time	Heliographic Diff. in longitude	Heliographic Longitude	Heliographic Latitude	Area Spot	Area Group	Total area for each day	Observatory
1936	h m	°	°	°				
Nov. 1	11 35	−54.0	252.9	−15.0		103		Harvard.
		−36.0	270.9	−14.0		172		
		−32.5	274.4	+20.5		63		
		−24.5	282.4	+19.5		14		
		−13.0	293.9	−19.0		40		
		−4.5	302.4	+18.5		238		
		−0.5	306.4	−24.5	14			
		+3.0	309.9	−13.0	13		657	

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Heliographic Diff. in longitude	Heliographic Longitude	Heliographic Latitude	Area Spot	Area Group	Total area for each day	Observatory
1936	h m	°	°	°				
Nov. 2	12 30	−68.0	225.3	+13.0	81			Mount Wilson.
		−68.0	225.3	−12.0	113			
		−50.0	243.3	−14.0		62		
		−41.0	252.3	−18.0		123		
		−24.0	269.3	−17.0		305		
		−16.0	277.3	+19.0		138		
		−2.0	291.3	−20.5	38			
		+6.0	299.3	+18.0		129		
		+14.0	307.3	−14.0		30	1,019	
Nov. 3	13 19	−56.0	223.6	+12.5	46			U. S. Naval.
		−55.0	224.6	−11.0	123			
		−37.0	242.6	−14.0		62		
		−36.0	243.6	−17.0		154		
		−25.0	254.6	−17.5		46		
		−15.0	264.6	−18.0		123		
		−8.5	271.1	−15.5		93		
		−3.0	276.6	+20.5		185		
		+11.0	290.6	−21.0	31			
		+20.0	299.6	+19.5		93		
		+29.0	308.6	−16.0		62	1,018	
Nov. 4	12 4	−83.0	184.1	+15.0	93			Do.
		−65.0	202.1	−13.0	31			
		−54.0	213.1	−14.0	15			
		−42.5	224.6	+13.0		46		
		−41.0	226.1	−11.0	123			
		−23.0	244.1	−16.5		216		
		−15.0	252.1	−17.5		93		
		−2.0	265.1	−18.0		154		
		+5.0	272.1	−15.0		93		
		+10.0	277.1	+20.0		247		
		+24.0	291.1	−21.0	31			
		+33.0	300.1	+19.0		15		
		+44.0	311.1	−15.0		31	1,188	
Nov. 5	11 22	−75.0	179.3	+14.0		309		Do.
		−62.0	192.3	−18.0		46		
		−52.0	202.3	−13.0		31		
		−39.5	214.8	−14.0	15			
		−30.0	224.3	+13.0	62			
		−29.0	225.3	−11.0	123			
		−11.0	243.3	−13.5		232		
		−9.0	245.3	−16.5		46		
		−1.0	253.3	−17.0		46		
		+10.5	264.8	−17.5		77		
		+19.0	273.3	−15.5		93		
		+20.0	274.3	+21.0		77		
		+26.5	280.8	+19.0	46		1,203	